ARTHROPOD SUCCESSORI INHABITING WILLOW GALLS DURING AUTUMN IN CHRISTCHURCH, NEW ZEALAND

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ABSTRACT

Arthropod (Hymenoptera: Tenthredinidae, Acarina: Eriophyoidea) induced galls on willow (*Salix fragilis, S.alba* var. *vitellina)* were inhabited by other arthropods during and after cecidozoan occupation. During autumn, food and climatic factors reduced the number and diversity of arthropods on the willow leaves. However, the percentage of arthropods inhabiting the galls increased during this time.

INTRODUCTION

Plant galls and the mechanisms of their formation have been reviewed by Felt (1940) and Mani (1964) with extensive bibliographies on this insect/plant relationship. Kammergalls of the sawfly *Pontania proxima* (Lepeletier) (Hymenoptera: Tenthredinidae) are fleshy, thick-walled hollow growths, that form like blisters on the leaves of willows *(Salix* spp.). They are oval to reniform in shape and normally are formed between the mid-vein and the leaf edge, projecting almost as much below as above the leaf blade.

The eggs of *P.proxima* are laid in the leaf tissue by the female sawfly. An enzyme, deposited at the time of egg deposition, initiates formation of the gall which continues to grow around a central cavity as the larva develops (Hovanitz 1959). An aperture in the gall is formed when the mature larva departs and a large amount of soft parenchyma tissue remains. This provides an ideal habitat for other phytophagous arthropods and for those seeking shelter (successori).

The first New Zealand record of the occurrence of this gall was on *Salix* sp. in South Canterbury (Muggeridge 1931). The gall was later recorded from *Salix babylonica* L. in Wellington (Lamb 1960), and is now common on *S. fragilis* L. in Christchurch.

White willow (*Salix alba* var. *vitellina* (L.) Ser.) is known to form edge roll galls as a result of stimulation by mites. These provide another habitat for successori. Feeding by minute unidentified mites of the superfamily Eriophyoidea results in unequal surface growth at the leaf margin causing the leaf to curl up. The eriophyoids are very small (100µm X 20µm) compared to the size of the gall induced by them (10mm X 2mm). This allows other insects, termed inquilines, to inhabit their galls at the same time. At present only one species of eriophyid mite is known from willow in New Zealand; an undescribed species of *Aculops* taken from undamaged leaves of *S.alba* L. (D.C.M. Manson, pers. comm.).

The willow leaves and galls in the present study provided a defined habitat for examination of species abundance, inter-relationships and faunal succession of insects, mites and other terrestrial arthropods.

The aim of this study was first to ascertain the insects living on willow leaves, second to determine if any of these were associated with the galls and the type of relationship, and third to describe the community structure on the leaves and note how this varied as autumn progressed until leaf fall occured.

STUDY AREAS

Leaves with kammergalls were collected from the only *Salix fragilis* (crack willow) tree in the Christchurch Botanical Gardens (Map Grid Ref: NZMS1:S84:560990). Several weeping willows (*S. babylonica*) also were examined but none possessed leaves with kammergalls. Kammergalls were collected also from *S. fragilis* beside the Styx River, Christchurch (Grid Ref: NZMS1: S76:030648). Most willow trees here were 8-12m high but a young, four metre, adventitious sprout was sampled during this study.

Leaves with edge roll galls were collected from *S.alba* var. *vitellina* (a white willow variety) in the University of Canterbury Grounds (Grid Ref: NZMS1:S84:567958). Weeping willow and weeping/white willow hybrids (*S. babylonica* X *S. alba* var. *vitellina)* from the University possessed neither edge roll nor kammergalls.

METHODS

SAMPLING

Samples were collected weekly in 1978 from 6 April until leaf fall which varied from 18 May to 8 June at the different sites. Each sample consisted of 25 galled leaves picked randomly from one tree. On three occasions samples of non-galled leaves were collected for a comparison of general fauna and population sizes.

LABORATORY OBSERVATIONS

Each leaf was examined under a binocular microscope (10X) and the following things determined: numbers of arthropod species living on the leaf and in the galls, number of open galls, and numbers of closed galls. Representative collections of each species were preserved in 90% ethyl alcohol or mounted on slides, and those allowed to emerge were pinned for later identification.

RESULTS

A complete list of the arthropods collected at the three sites is presented in Table 1.

TABLE 1. NUMBER OF ARTHROPODS COLLECTED FROM WILLOWS AT THE THREE SAMPLING SITES, APRIL TO JUNE 1978. (i = INSIDE KAMMERGALLS, t = TOTAL ON LEAVES, G = EDGE ROLL GALL INHABITANT, L = LEAF DWELLER).

		Kammergalls		Edge Roll Galls
		Styx River	Botanical Gardens	University Grounds
Tetranychus urticae (Acarina, Tetranychidae)	i	46	5	1 G
	t	1431	21	
Tydeus sp. (Acarina, Tydeidae)	i	156	857	1425 G
	t	1135	2175	
Caloglyphus rhizoglyphoides (Acarina, Acaridae)	i	14	22	63 G
	t	18	29	
Tortricid larvae (Lepidoptera, Tortricidae)	i	28	33	10 G
	t	44	37	
Cavariella aegopodii (Homoptera, Aphididae)	i	9	1	1 L
	t	90	5	
Book Lice (Psocoptera)	i	3	5	1 L
	t	34	18	
Anystis baccarum (Acarina, Anystidae)	i	0		
	t	1		
Pseudobonzia sp. (Acarina, Cunaxidae)	i		1	
	t		9	
Amblyseius largoensis (Acarina, Phytoseiidae)	i		3	
	t		6	
Scale insect (Homoptera, Coccoidea)	i		0	1 L
	t		16	
Ameroseus sp. (Acarina, Ameroseiidae)	i		0	
	t		2	
Others	i		0	
	t		4	
Lepidoptera (eggs)				9 L

A more diverse kammergall community containing larger numbers of most species was found on leaves from the Botanical Gardens than on those from the Styx River. However, whereas the edge gall community and the Botanical Gardens kammergall community were dominated by the mite *Tydeus* sp., the Styx River kammergall community was dominated approximately equally by the mites *Tydeus* sp. and *Tetranychus urticae* Koch (Table 1)

The species diversity of the kammergall community declined from April to mid June, as weekly maximum temperature dropped from 22 C to 9 C. The number of arthropods occupying galls increased, from 6 April to 4 May, probably in response to falling temperatures and increased rainfall (137mm in the week ending 21 April).

STYX RIVER

Three samples (each N=25 leaves) were collected on 4 May, two of galled leaves and one of ungalled leaves (Table 2). Mean numbers of all arthropods per leaf were 17,5, 7.8, and 4.6 respectively but differences between the two galled samples were not significant (X^2=3.72,d.f.=1,P>0.05). When individual galled samples were compared with the ungalled sample, one was significantly different (X^2=7.52,d.f.=1P>0.10). This variability from tree to tree shows the difficulty experienced in interpreting associations between the arthropods found and galls present.

TABLE 2. NUMBER OF ARTHROPODS AND KAMMERGALLS COLLECTED FROM GALLED LEAVES OF *SALIX FRAGILIS* AT THE STYX RIVER, APRIL TO MAY 1978.

	April			May			
Styx River	6	21	28	4	4	4*	18
Number of leaves in each sample	17	25	25	25	25	25	16
Total number of Arthropods in each sample	322	1389	339	438	196	116	262
Number of arthropods inside galls	24	76	39	98	29		19
Mean number of arthropods on each leaf	18.9	55.6	13.6	17.5	7.8	4.6	16.4
Total number of galls in each sample	103	126	81	83	71	0	37
Number of open galls in each sample	73	73	37	38	47		24
Mean number of galls on each leaf	6.1	5.0	3.2	3.3	2.8		2.3
Mean number of arthropods per gall	3.1	11.0	4.2	5.3	2.8		7.1
Mean number of arthropods in each open gall	0.3	1.0	1.1	2.6	0.6		0.8

* = sample of non-galled leaves

The most common species observed were the mites *T.urticae* and *Tydeus* sp. Numbers of each species were similar and made up almost the entire community (Fig.1). Small numbers of the predatory mite *Caloglyphus rhizoglyphoides* (Zachvatkin)

were collected in late April-early May. One specimen of *Anystis baccarum* feeding on *Tydeus* sp. was also observed. The common carrot aphid *Cavariella aegopodii* (Scopoli) was collected frequently until the beginning of May. Tortricid larvae were also found on leaves and many were observed feeding on soft tissue inside the galls. A tachinid fly (*Pales funestra* (Hutton)) parasitic on leaf rollers emerged from a tortricid pupa in the laboratory. *T. urticae*, *Tydeus* sp., *C. rhizoglyphoides*, and tortricid larvae comprised more than 95% of the total fauna on the leaves. It appeared these were associated with galls because their populations were higher on the galled leaves than on the ungalled leaves. The percentage of the two most common mites inside the galls, compared to the total numbers on the leaves, fluctuated. Numbers of *T.urticae* inside the galls was never more than 10% compared to 40% of *Tydeus* sp. Tortricid larvae showed more definite associations with galls. 55% of larvae were in galls in April and this increased to 85% in mid June, just prior to leaf fall (Fig. 4). The aphid *C. aegopodii* was not considered to be closely associated with galls, which contained a maximum of 16% of individuals present on a leaf.

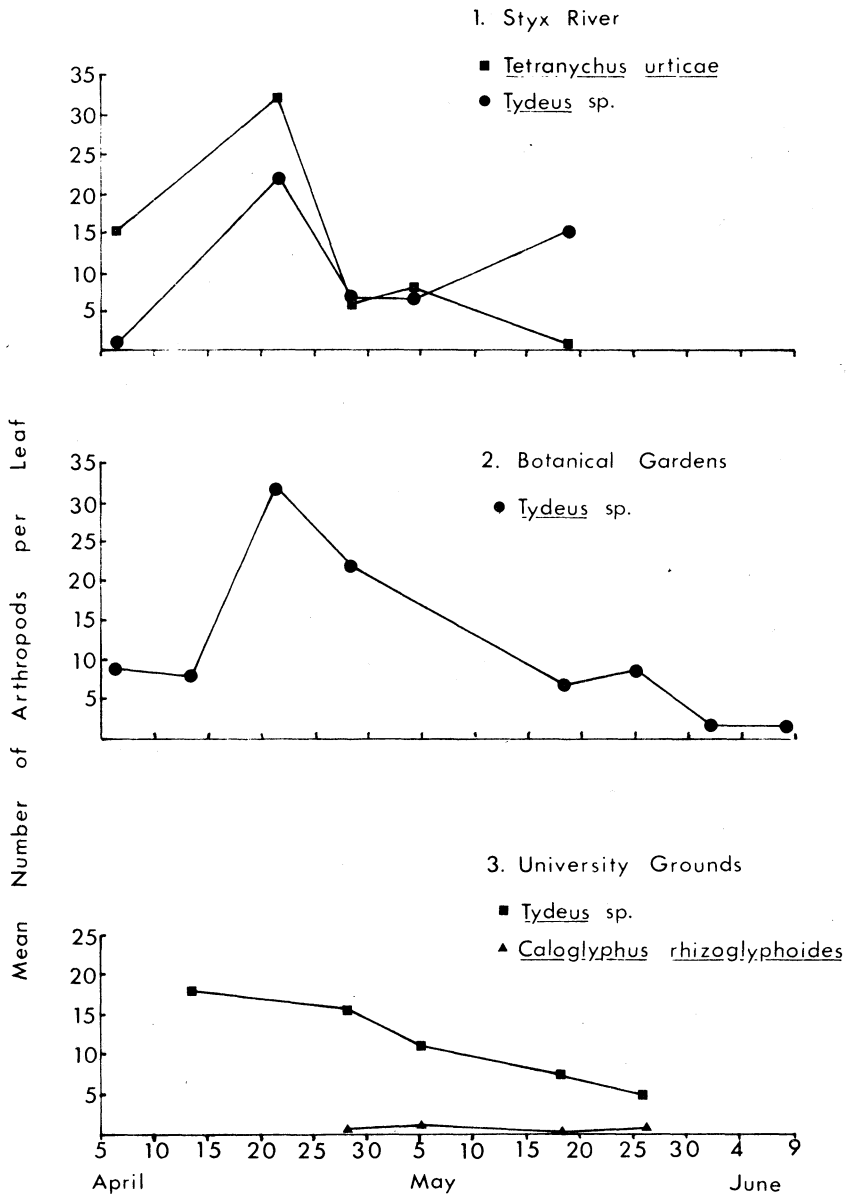
BOTANICAL GARDENS

Three species, the mites *Tydeus* sp. and *Caloglyphus rhizoglyphoides* and the tortricid larvae, comprised most of the fauna on the leaves. Total number of arthropods were significantly higher on galled than on non-galled leaves ($X^2=7.14$,d.f.=1,$P>0.01$) on 13 April (Table 3).

Tydeus sp. was the most abundant species at the Botanical Gardens (Fig.2). Most mites were found in a small trough surrounding the gall on the underside of the leaf, but many were sheltering along the midrib. The number of *Tydeus* sp. inside galls, compared to total numbers on the leaves, was less than 50% during April, but this increased to 80% by mid-June (Fig.5). The predatory mite *C. rhizoglyphoides* appeared a week after the population of *Tydeus* sp. had attained its maximum size, and maintained low numbers until leaf fall. Numbers of *C. rhizoglyphoides* inside galls was never less than 50% of the total leaf population. Small numbers of tortricid larvae also were present, especially in the galls (Fig.5) and gradually increased during autumn. Few *T. urticae* were found, and on occasions they were absent from some samples. Sometimes when a gall was cut open for examination, a white fungus was found growing on a dead tortricid larva. Other arthropods were found in low numbers and can be described as vagrants.

UNIVERSITY GROUNDS

Only three organisms, the mites *Tydeus* sp. and *C. rhizoglyphoides* and the tortricid larvae occured in sufficient numbers to be classed as other than vagrants. Total numbers of arthropods were higher on galled than on non-galled leaves on 4 and 5 May (Table 4) *Tydeus* sp. made up almost all the inquilines, with the predatory mite *C.rhizoglyphoides*



Figs. 1-3. Changes in the number of dominant arthropods collected from galled leaves of willow at three sites, April to June 1978.

Fig. 1. Number of *Tetranychus urticae* and *Tydeus* sp. from *Salix fragilis* at the Styx River.

Fig. 2. Number of *Tydeus* sp. from *S. fragilis* at the Botanical Gardens.

Fig. 3. Number of *Tydeus* sp. and *Caloglyphus rhizoglyphoides* from *S. alba* var. *vitellina* at the University of Canterbury.

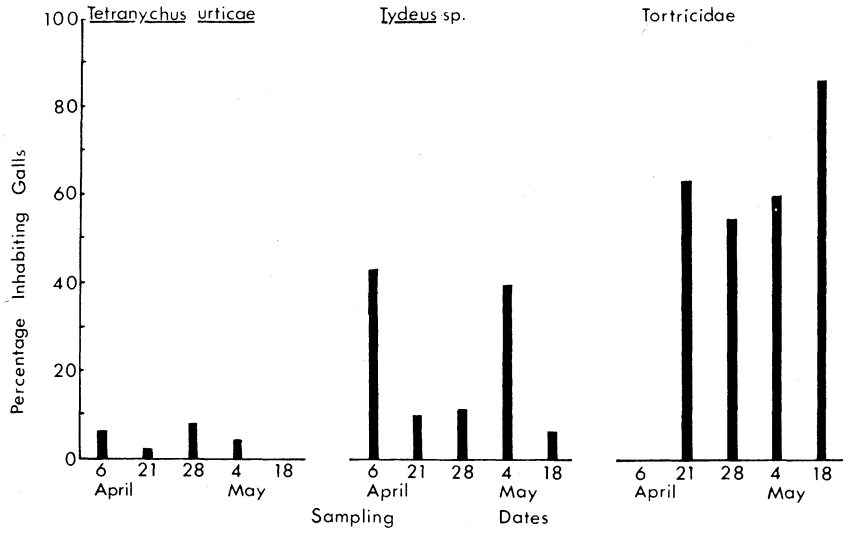


Fig.4. Gall inhabition by the dominant arthropods, on the leaves of *Salix fragilis* at the Styx River, April to May 1978.

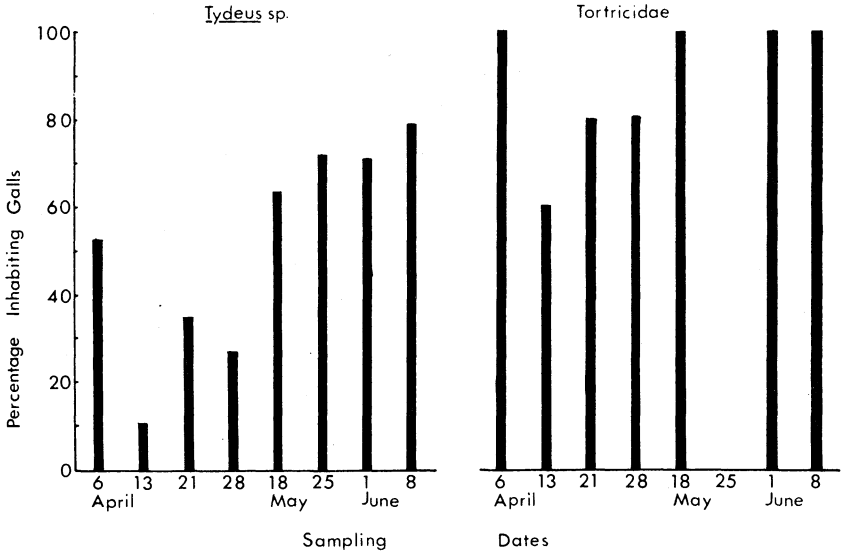


Fig. 5. Gall inhabition by the dominant arthropods, on the leaves of *Salix fragilis* at the Botanical Gardens, April to June 1978.

maintaining a small population (Fig.3). Several tortricid larvae were collected from depressions in the leaves, but most were living in the galls.

TABLE 3. NUMBER OF ARTHROPODS AND KAMMERGALLS COLLECTED FROM GALLED LEAVES OF *SALIX FRAGILIS* AT THE BOTANICAL GARDENS, APRIL TO JUNE 1978.

	April					May		June	
	6	13	13*	21	28	18	25	1	8
Number of leaves in each sample	18	25	25	25	25	25	25	25	25
Total number of arthropods in each sample	178	251	28	816	549	204	222	58	47
Number of arthropods inside galls	95	33		285	152	130	159	41	38
Mean number of arthropods on each leaf	9.9	10.0	1.1	32.6	22.0	8.2	8.9	2.3	2.0
Total number of galls in each sample	73	83	0	146	84	87	101	72	62
Number of open galls in each sample	62	67		121	66	75	92	57	53
Mean number of galls on each leaf	3.9	3.3		5.8	3.4	3.5	4.0	2.9	2.6
Mean number of arthropods per gall	2.5	3.0		5.6	6.5	2.4	2.2	0.8	0.8
Mean number of arthropods in each open gall	1.5	0.5		2.4	2.3	1.7	1.7	0.7	0.7

* = sample of non galled leaves.

TABLE 4. NUMBER OF ARTHROPODS AND EDGE ROLL GALLS COLLECTED FROM GALLED LEAVES OF *SALIX ALBA* VAR. *VITELLINA* IN THE UNIVERSITY GROUNDS APRIL TO MAY 1978.

	April		May			
University Grounds	13	28	4*	5	18	26
Number of leaves in each sample	25	20	25	25	25	25
Total number of arthropods in each sample	473	339	29	320	202	140
Mean number of arthropods on each leaf	18.9	17.0	1.2	12.8	8.1	5.6
Total number of galls in each sample	165	104	0	210	114	88
Mean number of arthropods per gall	2.9	3.3		1.5	1.8	1.6
Mean number of galls on each leaf	6.6	5.2		8.4	4.6	3.5

* = sample of non-galled leaves.

DISCUSSION

This study provides information on the composition of the community inhabiting galled leaves of willow. However, it covers only a short period of the year and therefore is not a description of the complete cycle of leaf and gall dwellers.

Members of the fauna, especially mites, moved little during the collecting and examination times (1000 - 1700 h), suggesting that little movement from leaf to leaf occurs by day. It was felt therefore that it was safe to assume that movement after sampling and before examination was insignificant. Also, I assumed that the number of galled leaves at each study site was sufficient to tolerate sampling pressure except perhaps during leaf fall.

A number of workers have found that variation is often greater between trees than within a single tree. Hence samples from many trees may be more useful than large numbers of leaves taken from a few trees (Oakland 1953). This is borne out by the significant difference in population numbers of two samples of galled leaves taken on the same day at the Styx River from two willows.

The mites *T.urticae* and *Tydeus* sp. were associated with galls. They were not very active between April and June, but most were feeding during this time. Galls increased the number of sheltered areas on the leaves and so allowed increased populations to occur there. Although the total number of mites per leaf decreased during the period of the study, the proportion inside galls increased. This was probably because they are better protected and consequently survive longer inside galls. By inhabiting the underside of leaves, mites presumably are sheltered from rain. Living inside galls may protect them from frosts and thereby delay the transition to an overwintering stage.

The community structure (Fig.6) was simple and was most affected by leaf fall. As leaves are the food for the primary consumers and provide the habitat for all species, leaf fall is a critical time for those not ready to overwinter or find a new habitat.

The edge gall community and the Botanical Gardens kammergall community were dominated by the mite *Tydeus* sp. The Styx River kammergall community was dominated almost equally by the mites *Tydeus* sp. and *T.urticae*. Tortricid larvae at the Botanical Gardens apparently always occupied galls, whereas larvae at the Styx River achieved up to 90% habitiation only in June. The average number of arthropods per leaf was usually less at the Botanical Gardens although the number of galls per leaf was the same.

Weather and differences in microclimate probably influenced (or brought about) differences in population size observed at the three localities. Thus, the Styx River trees were taller and more exposed than those at the Botanical Gardens, and leaf fall occured three weeks later at the Gardens.

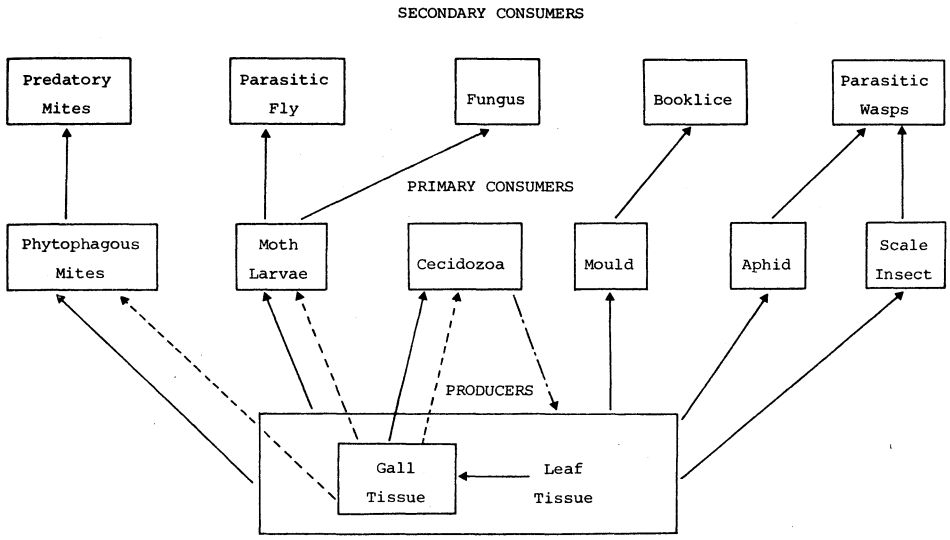


Fig 6. Structure of the kammergall/leaf community on *Salix fragilis*. Feeding (———), shelter(·····), gall formation(—·—·—).

In summary, this study has presented a picture of the types of arthropods living on the willow and has shown that galls offer protection to arthropods, allowing larger and more durable populations to occur.

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